Fog Effect, Mouse picking
and
GLSL Intrinsic Functions

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Fog

- To simulate certain types of weather conditions in our games, we need to be able to implement a fog effect.
- Provides some fringe benefits
- *Popping* refers to an object that was previously behind the far plane all of a sudden coming in front of the frustum, due to camera movement, and thus becoming visible

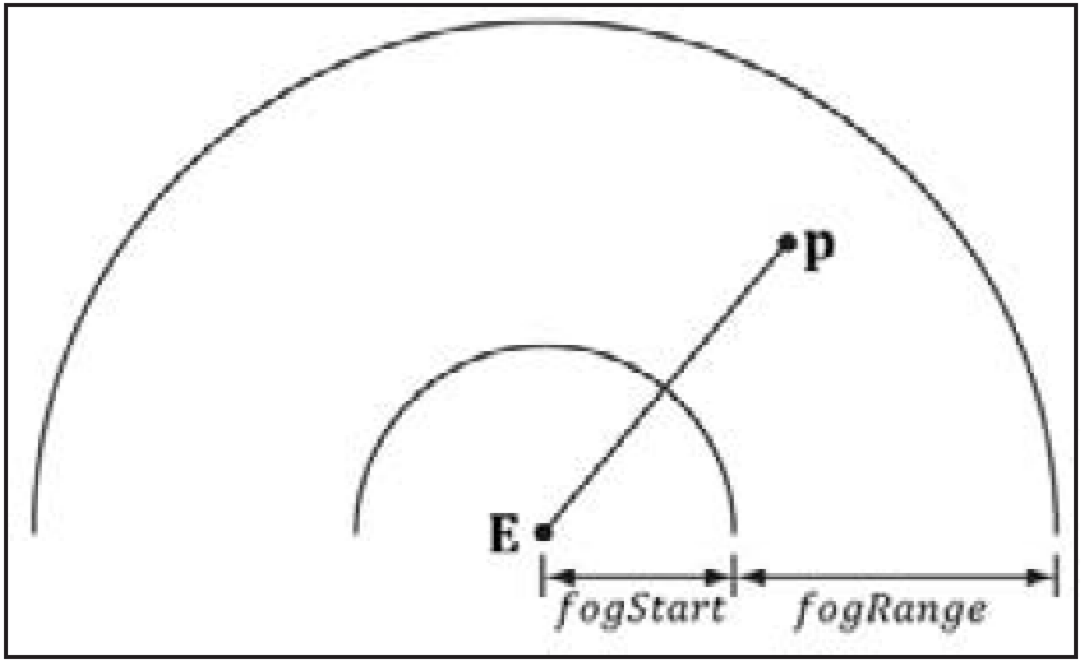
Fog

- if your scene takes place on a clear day, you may still wish to include a subtle amount of fog at far distances, because, even on clear days, distant objects such as mountains appear hazy and lose contrast as a function of depth
- We can use fog to simulate this *atmospheric perspective* phenomenon.

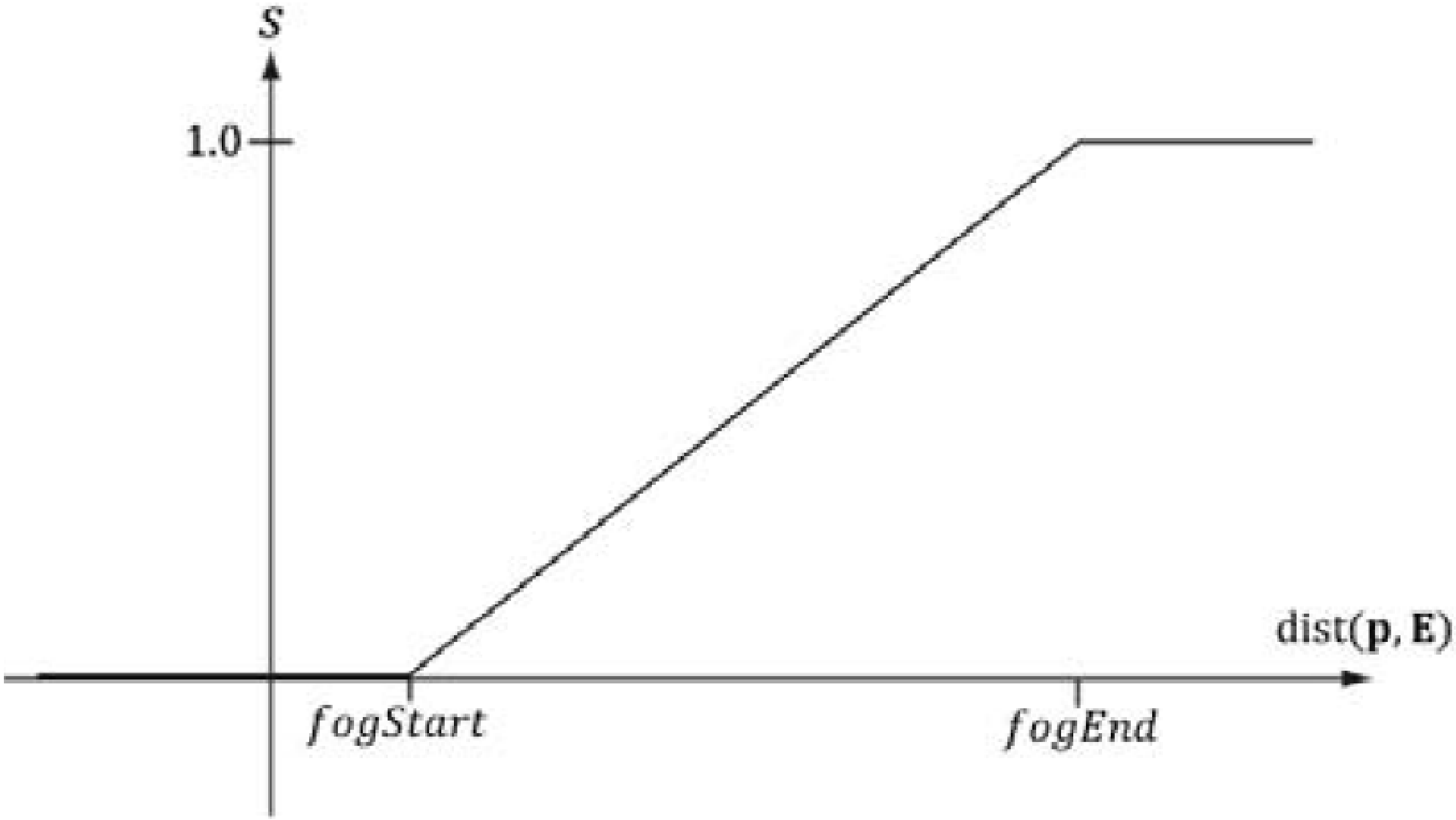
Fog

- We specify
  - a fog color,
  - a fog start distance from the camera,
  - and a fog range
- Then the color of a point on a triangle is a weighted average of its usual color and the fog color

Fog



Fog



Fog

$$\frac{dist(\mathbf{p},\mathbf{E}) - fogStart}{fogRange}$$

Fog

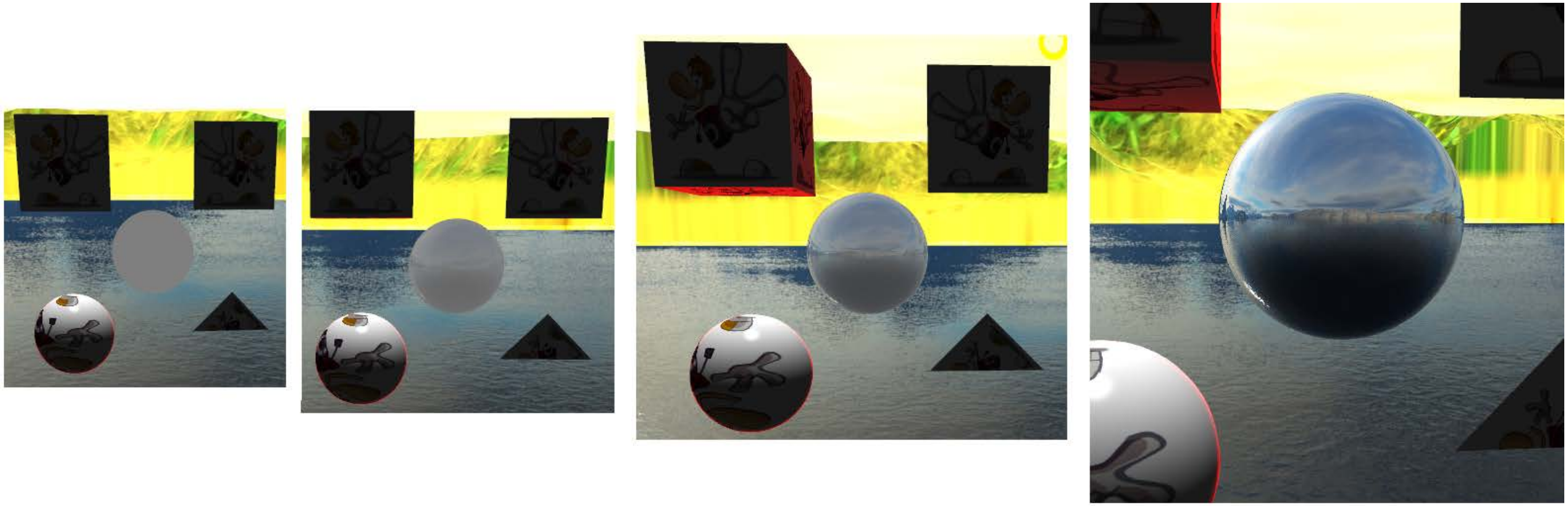
```
//** Vertex Shader
vec4 mWorldPos = model *vec4(position, 1.0);
gl_Position =  proj * view * worldPos;

//** fragment shader
float d = distance(mWorldPos.xyz, cameraPos);
float lerp = (d - 5.0f)/10.f;
lerp = clamp(lerp, 0.0, 1.0);

vec4 vFogColor = vec4(0.5f, 0.5f, 0.5f, 1.0f);

color = mix(color, vFogColor, lerp);
```

Fog



3D Mouse Picking

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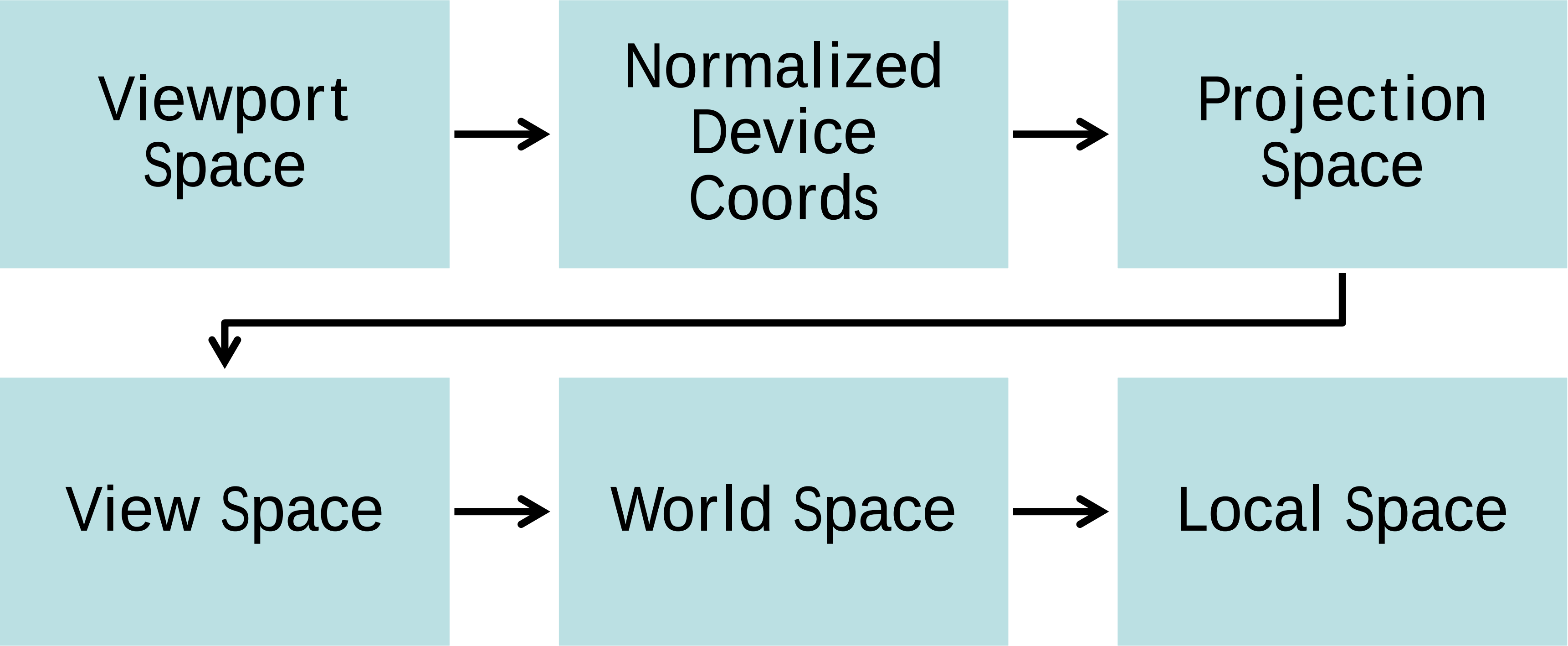
Mouse Picking



Viewport Space

Normalized Device Coords

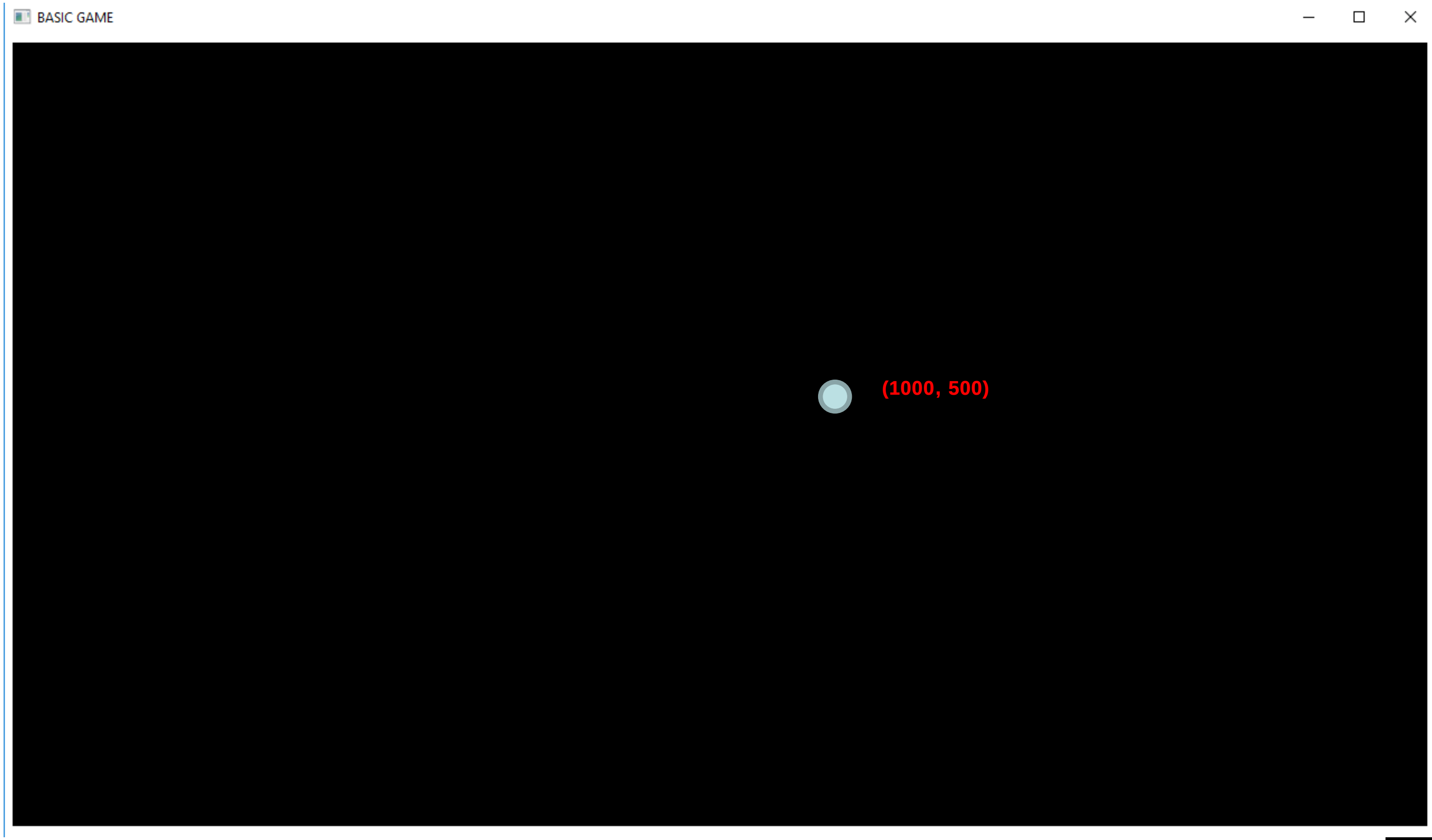
Projection Space

View Space

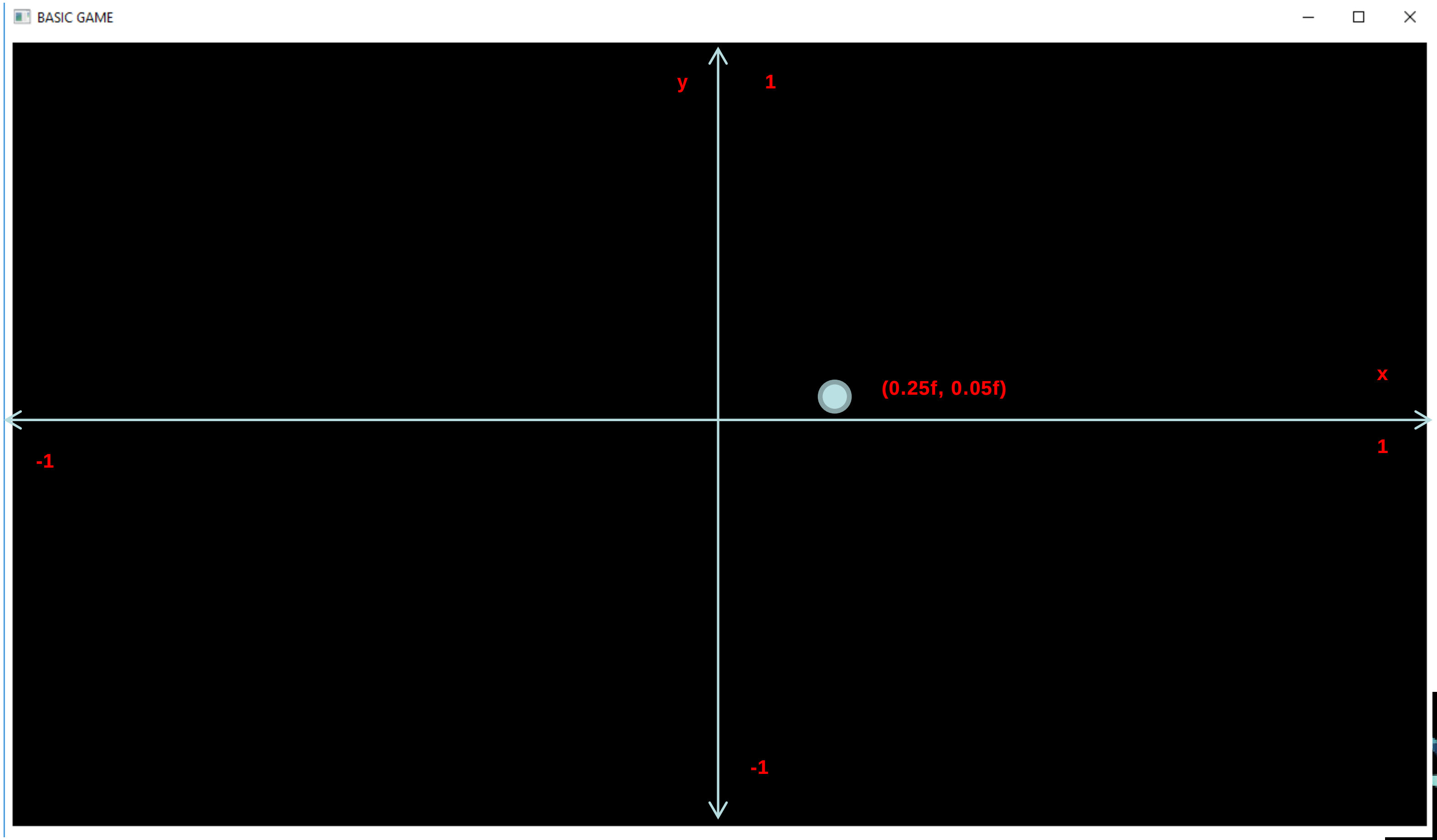
World Space

Local Space

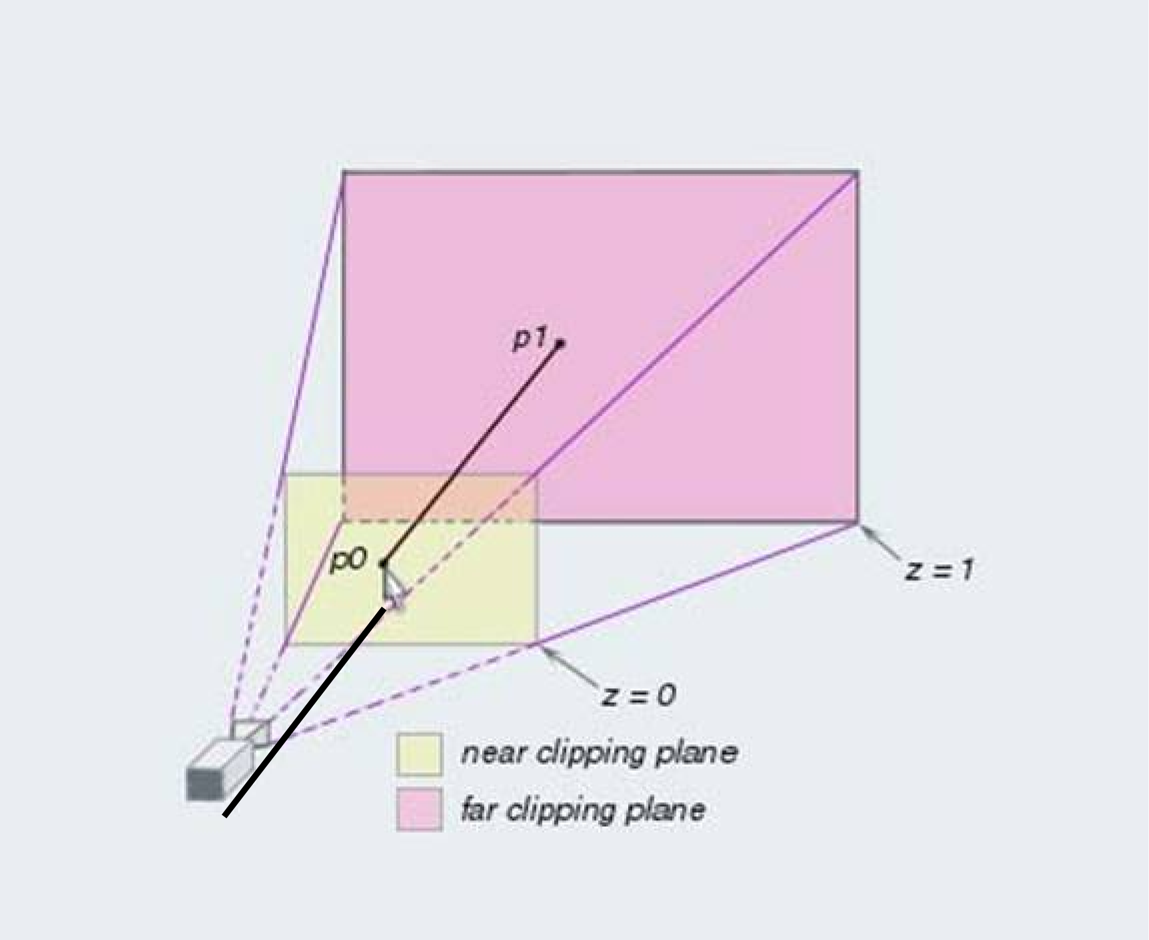
Viewport Space



Normalized Device Coords



Projected Ray



Mouse Picking

- Create variables in main.cpp to store values

  ```
  glm::vec3 rayDirection;
  float mouseY;
  float mouseX;
  ```

- In mousePassive function set the values of mouseX and mouseY. Converted to NDC.

```
mouseX = (2.0f * x) / (float)Utils::WIDTH - 1.0f;
mouseY = 1.0f - (2.0f * y) / (float)Utils::HEIGHT;
```

Mouse Picking

- Create new function **updateMousePicking** add following to it.

```
bool updateMousePicking(){
//screen pos
glm::vec2 normalizedScreenPos = glm::vec2(mouseX, mouseY);

//screenpos to Proj Space
glm::vec4 clipCoords = glm::vec4(normalizedScreenPos.x, normalizedScreenPos.y, -1.0f, 1.0f);

//Proj Space to eye space
glm::mat4 invProjMat = glm::inverse(camera->getprojectionMatrix());
glm::vec4 eyeCoords = invProjMat * clipCoords;
eyeCoords = glm::vec4(eyeCoords.x, eyeCoords.y, -1.0f, 0.0f)
```

Mouse Picking

```
    //eyespace to world space
    glm::mat4 invViewMat = glm::inverse(camera->getViewMatrix());
    glm::vec4 rayWorld = invViewMat * eyeCoords;
    rayDirection = glm::normalize(glm::vec3(rayWorld));

    //add code to check
    // intersection with other objects
}
```

- Following code checks intersection of ray with a sphere of radius 1.0f.
- Similarly intersection with other shapes can be added.
- Most Physics engines has code for checking intersection with physics objects.

Check intersection with Object

```
    float radius = 1.0f;
    glm::vec3 v = sphere->getPosition() - camera->getCameraPosition();

    float a = glm::dot(rayDirection, rayDirection);
    float b = 2 * glm::dot(v, rayDirection);
    float c = glm::dot(v, v) - radius * radius;
    float d = b * b - 4 * a* c;

if (d > 0) {
    float x1 = (-b - sqrt(d)) / 2;
    float x2 = (-b + sqrt(d)) / 2;
    if (x1 >= 0 && x2 >= 0) return true; // intersects
    if (x1 < 0 && x2 >= 0) return true; // intersects
}else if (d <= 0) {
    return false;// no intersection
}
```

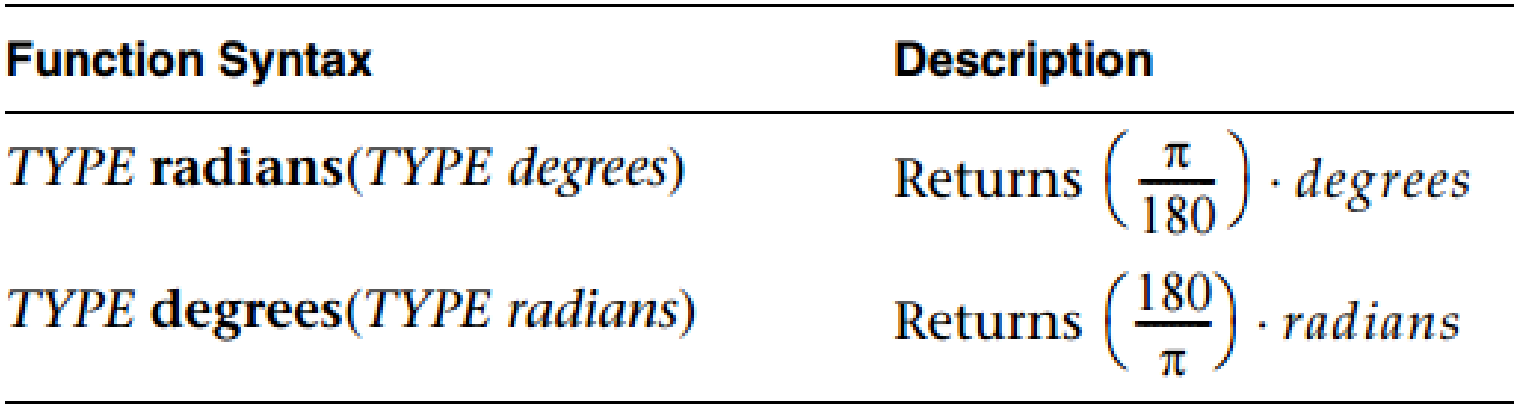
Mouse Picking

- Add updateMousePicking function to your update function.

Built-In OpenGL Shading Language Functions

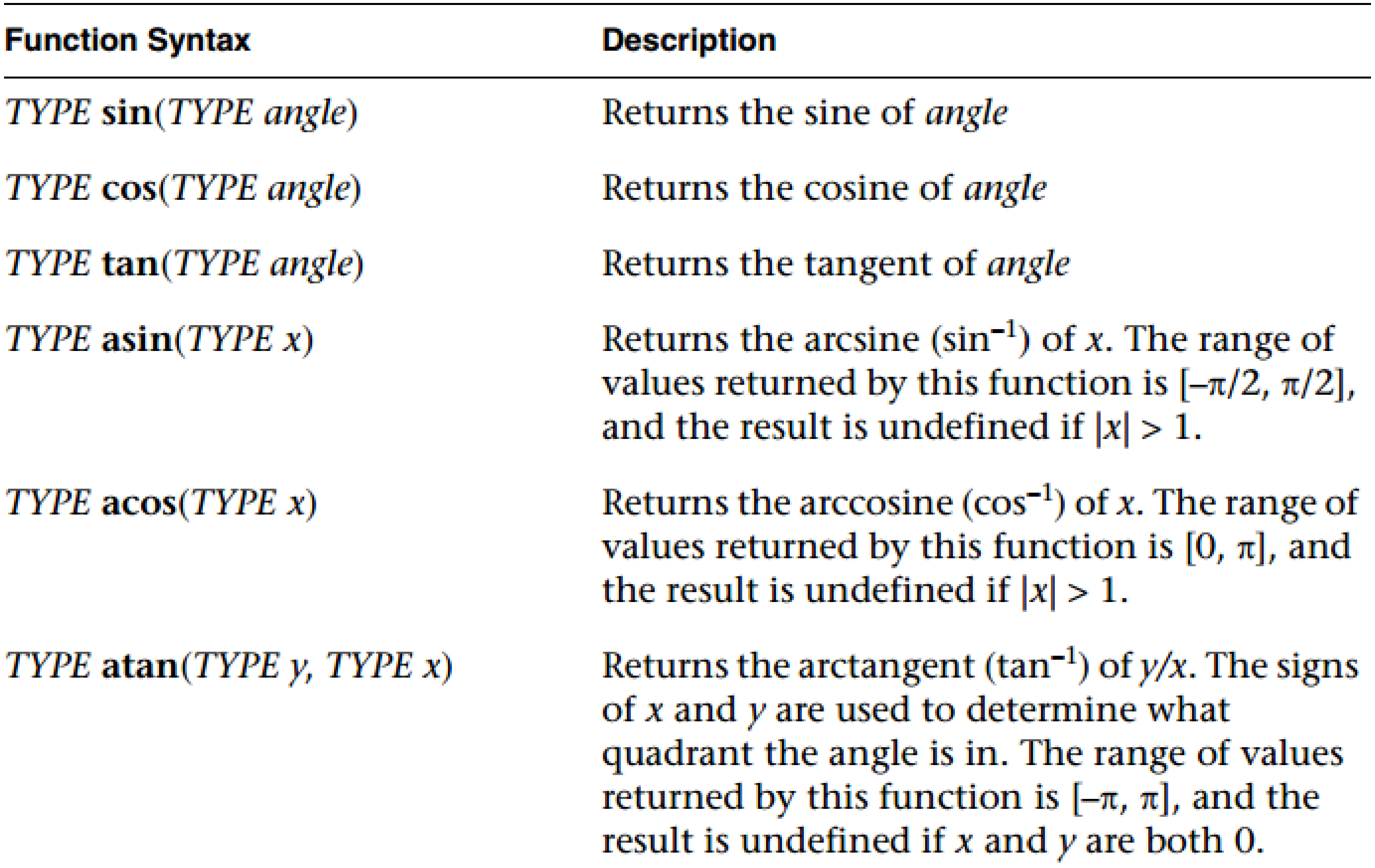
Built-In OpenGL Shading Language Functions

- Angle Conversion and Trigonometry Functions



Function Syntax	Description
TYPE **radians**(*TYPE degrees*)	Returns $\left(\frac{\pi}{180}\right) \cdot degrees$
TYPE **degrees**(*TYPE radians*)	Returns $\left(\frac{180}{\pi}\right) \cdot radians$

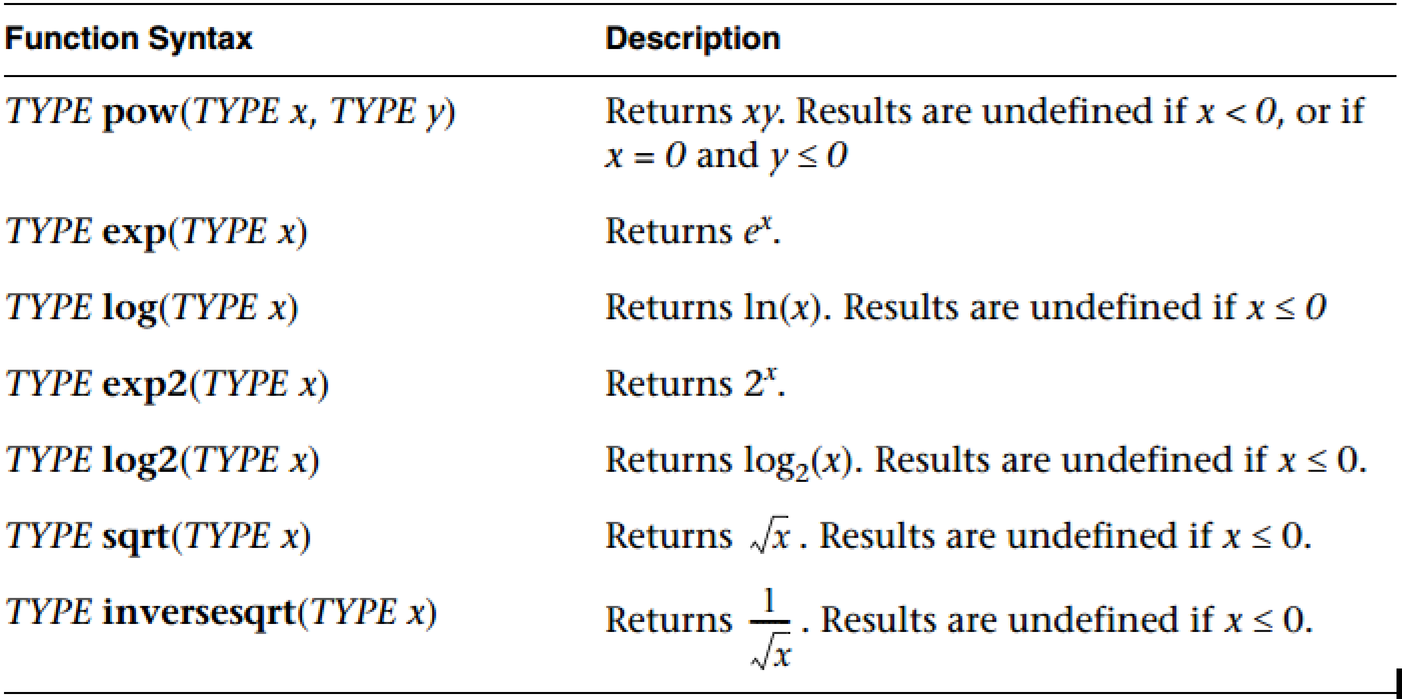
Built-In OpenGL Shading Language Functions



Function Syntax	**Description**
TYPE **sin**(*TYPE angle*)	Returns the sine of *angle*
TYPE **cos**(*TYPE angle*)	Returns the cosine of *angle*
TYPE **tan**(*TYPE angle*)	Returns the tangent of *angle*
TYPE **asin**(*TYPE x*)	Returns the arcsine ($\sin^{-1}$) of x. The range of values returned by this function is $[-\pi/2, \pi/2]$, and the result is undefined if $\lvert x \rvert > 1$.
TYPE **acos**(*TYPE x*)	Returns the arccosine ($\cos^{-1}$) of x. The range of values returned by this function is $[0, \pi]$, and the result is undefined if $\lvert x \rvert > 1$.
TYPE **atan**(*TYPE y*, *TYPE x*)	Returns the arctangent ($\tan^{-1}$) of y/x. The signs of x and y are used to determine what quadrant the angle is in. The range of values returned by this function is $[-\pi, \pi]$, and the result is undefined if x and y are both 0.

Built-In OpenGL Shading Language Functions

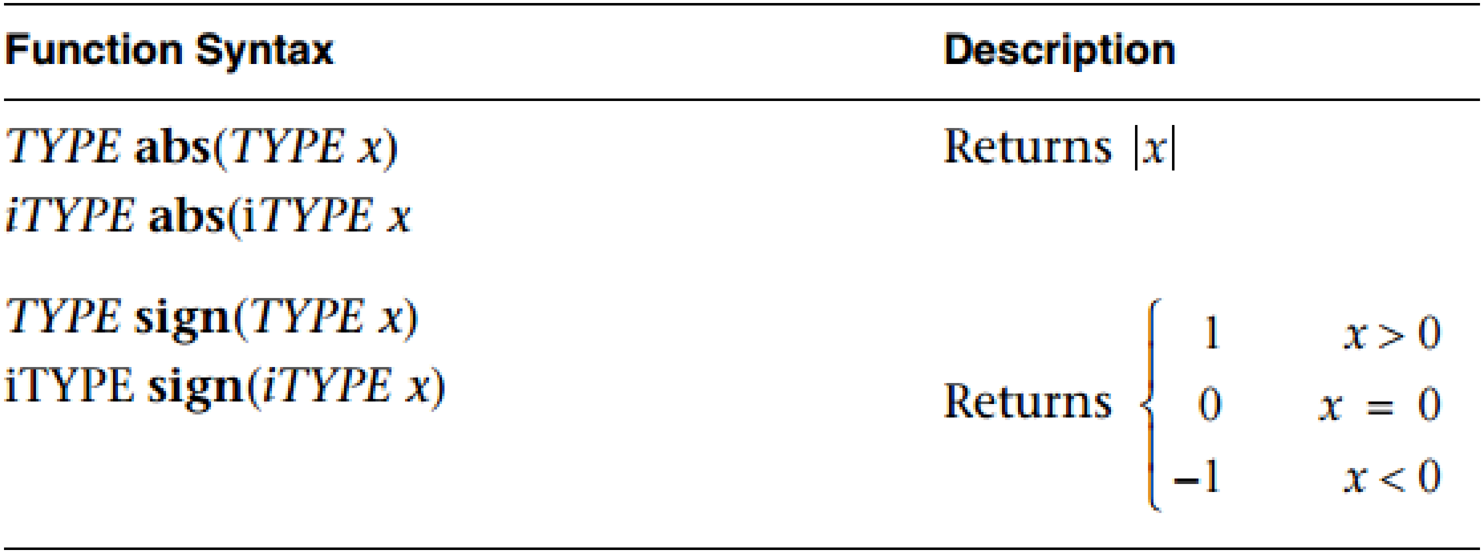
- Transcendental Functions



Function Syntax	Description
TYPE **pow**(*TYPE x*, *TYPE y*)	Returns xy. Results are undefined if $x < 0$, or if $x = 0$ and $y \leq 0$
TYPE **exp**(*TYPE x*)	Returns e^x.
TYPE **log**(*TYPE x*)	Returns $\ln(x)$. Results are undefined if $x \leq 0$
TYPE **exp2**(*TYPE x*)	Returns 2^x.
TYPE **log2**(*TYPE x*)	Returns $\log_2(x)$. Results are undefined if $x \leq 0$.
TYPE **sqrt**(*TYPE x*)	Returns $\sqrt{x}$. Results are undefined if $x \leq 0$.
TYPE **inversesqrt**(*TYPE x*)	Returns $\frac{1}{\sqrt{x}}$. Results are undefined if $x \leq 0$.

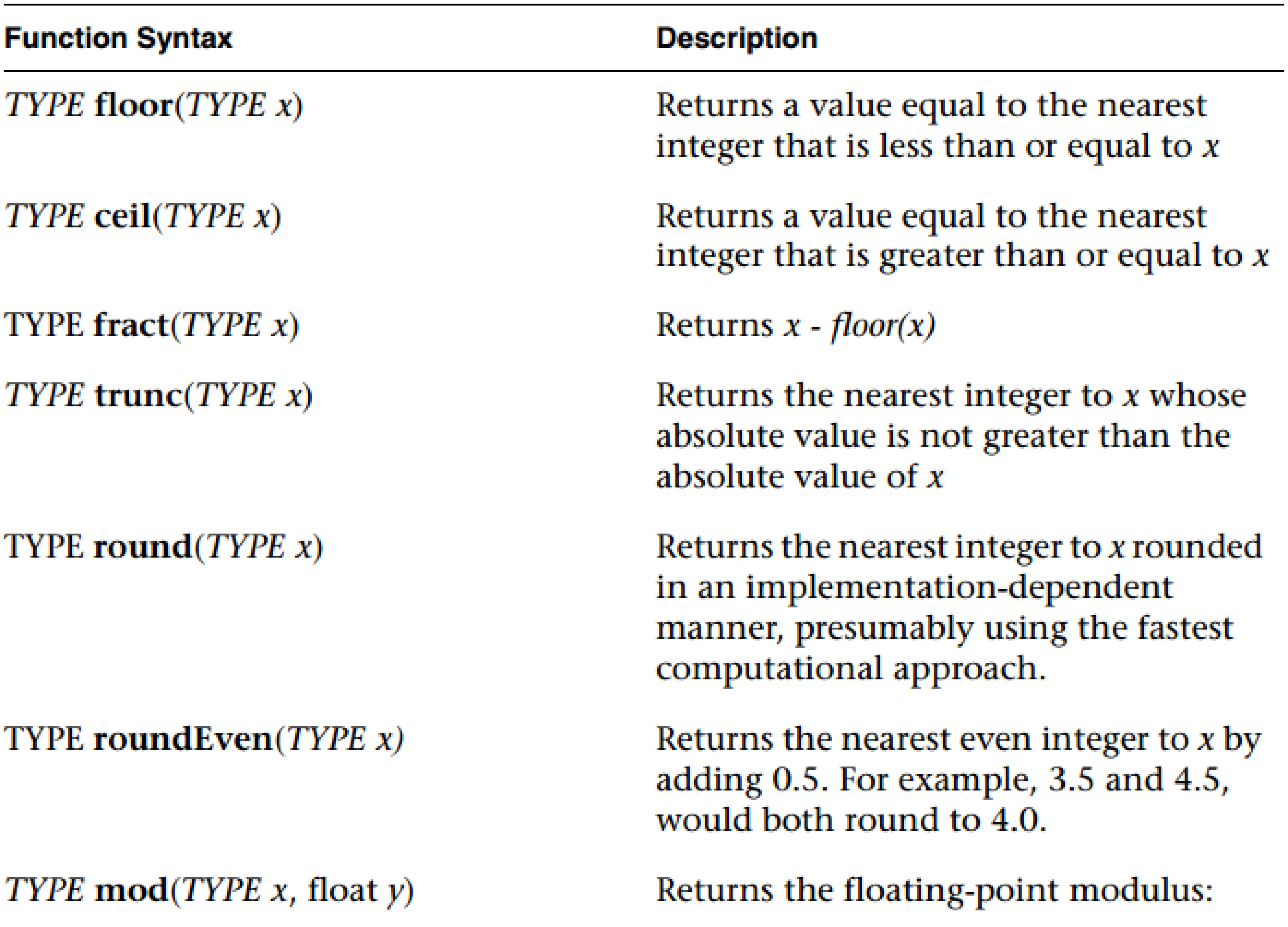
Built-In OpenGL Shading Language Functions

- Basic Numerical Functions



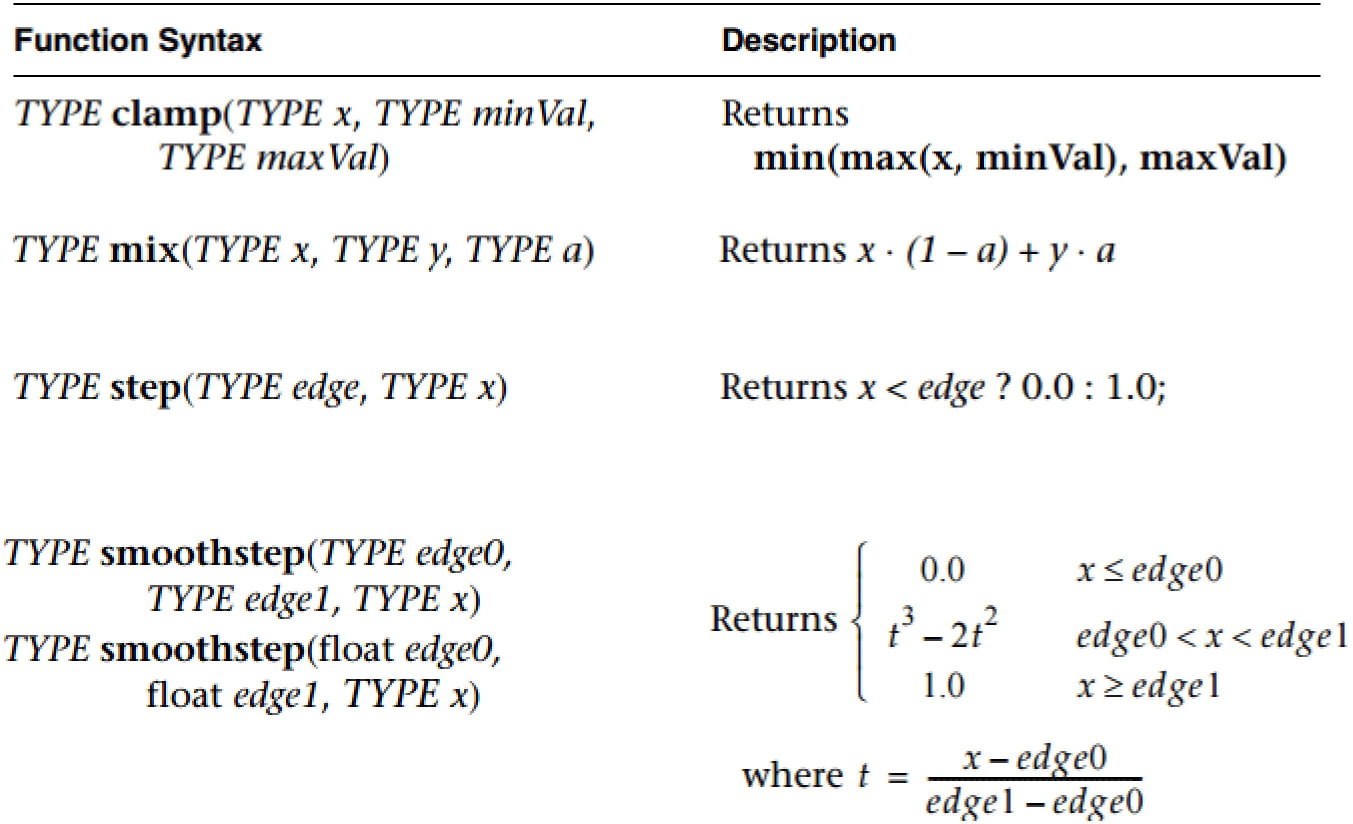
Function Syntax	Description
TYPE **abs**(*TYPE x*) *iTYPE* **abs**(i*TYPE x*	Returns $\lvert x \rvert$
TYPE **sign**(*TYPE x*) iTYPE **sign**(*iTYPE x*)	Returns $\begin{cases} 1 & x > 0 \\ 0 & x = 0 \\ -1 & x < 0 \end{cases}$

Built-In OpenGL Shading Language Functions



Function Syntax	Description
TYPE **floor**(*TYPE x*)	Returns a value equal to the nearest integer that is less than or equal to *x*
TYPE **ceil**(*TYPE x*)	Returns a value equal to the nearest integer that is greater than or equal to *x*
TYPE **fract**(*TYPE x*)	Returns *x* - *floor(x)*
TYPE **trunc**(*TYPE x*)	Returns the nearest integer to *x* whose absolute value is not greater than the absolute value of *x*
TYPE **round**(*TYPE x*)	Returns the nearest integer to *x* rounded in an implementation-dependent manner, presumably using the fastest computational approach.
TYPE **roundEven**(*TYPE x*)	Returns the nearest even integer to *x* by adding 0.5. For example, 3.5 and 4.5, would both round to 4.0.
TYPE **mod**(*TYPE x*, float *y*)	Returns the floating-point modulus:

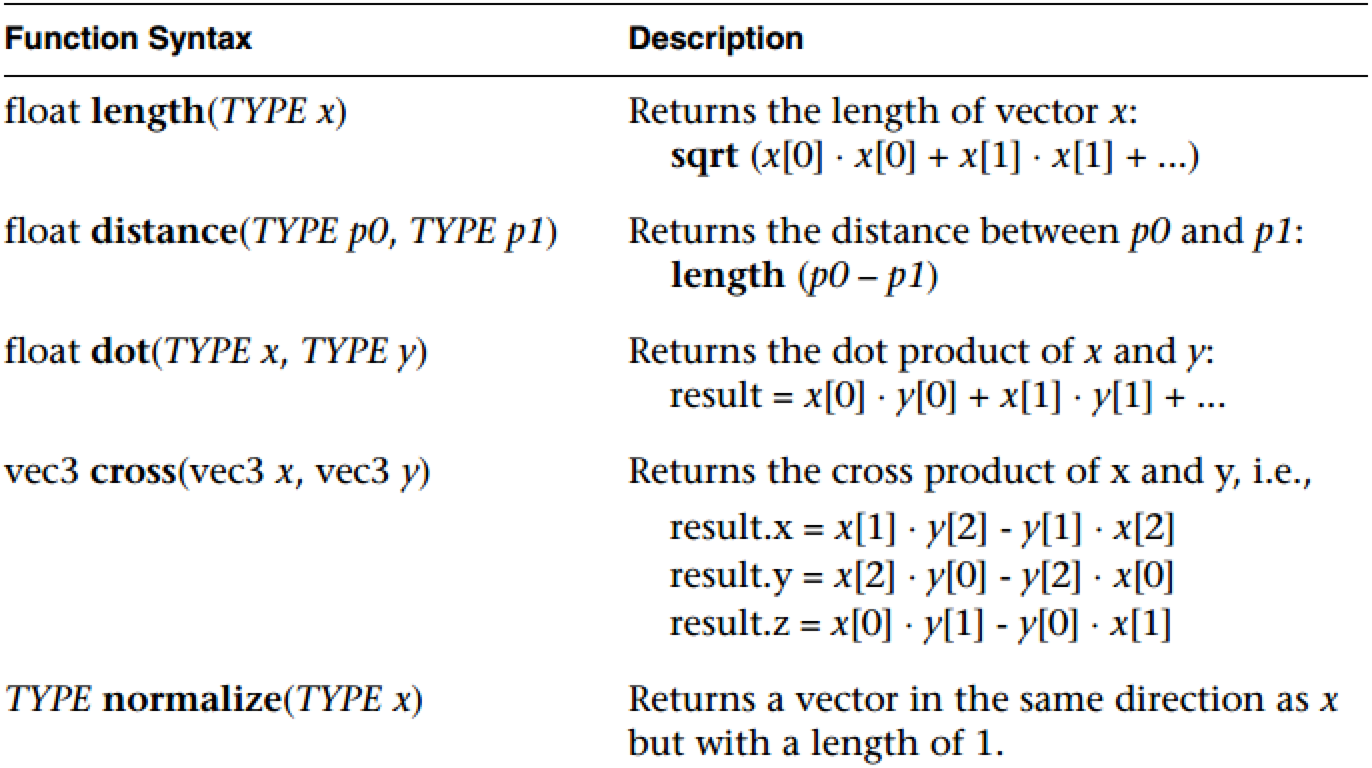
Built-In OpenGL Shading Language Functions



Function Syntax	Description
TYPE **clamp**(*TYPE x*, *TYPE minVal*, *TYPE maxVal*)	Returns **min(max(x, minVal), maxVal)**
TYPE **mix**(*TYPE x*, *TYPE y*, *TYPE a*)	Returns $x \cdot (1 - a) + y \cdot a$
TYPE **step**(*TYPE edge*, *TYPE x*)	Returns $x < edge$? 0.0 : 1.0;
TYPE **smoothstep**(*TYPE edge0*, *TYPE edge1*, *TYPE x*) *TYPE* **smoothstep**(float *edge0*, float *edge1*, *TYPE x*)	Returns $\begin{cases} 0.0 & x \le edge0 \\ t^3 - 2t^2 & edge0 < x < edge1 \\ 1.0 & x \ge edge1 \end{cases}$ where $t = \dfrac{x - edge0}{edge1 - edge0}$

Built-In OpenGL Shading Language Functions

- Vector Operations

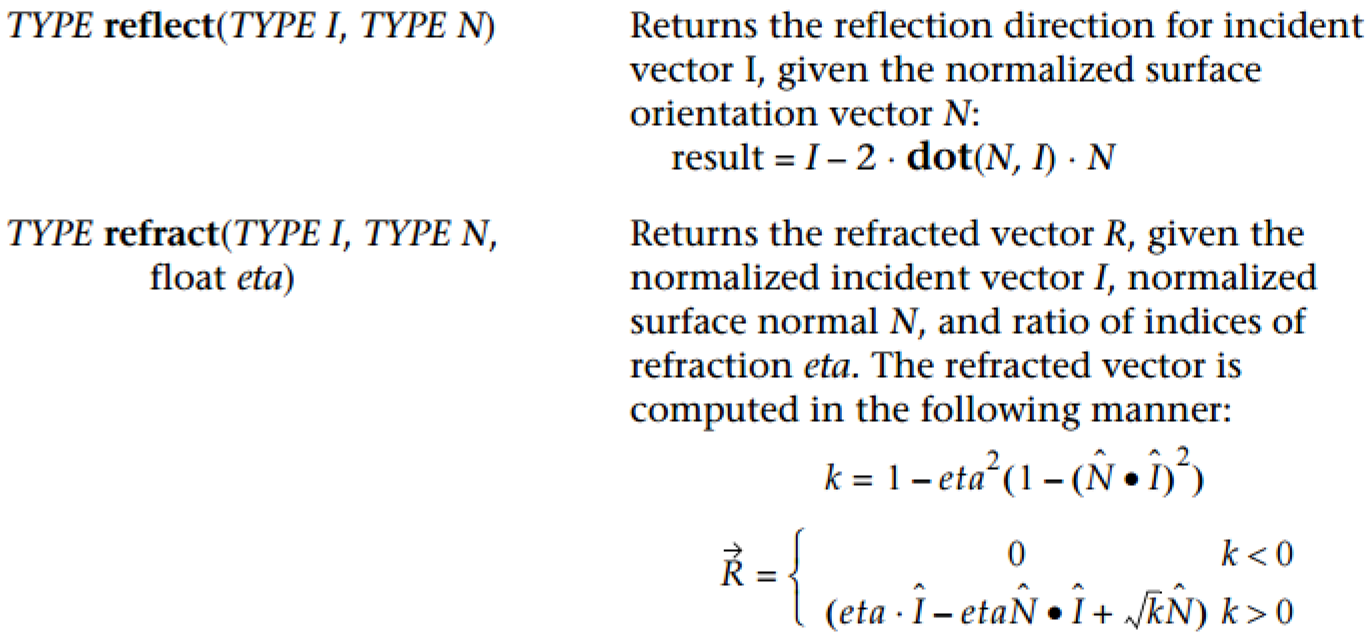


Function Syntax	Description
float **length**(*TYPE x*)	Returns the length of vector *x*: **sqrt** (*x*[0] · *x*[0] + *x*[1] · *x*[1] + ...)
float **distance**(*TYPE p0, TYPE p1*)	Returns the distance between *p0* and *p1*: **length** (*p0* – *p1*)
float **dot**(*TYPE x, TYPE y*)	Returns the dot product of *x* and *y*: result = *x*[0] · *y*[0] + *x*[1] · *y*[1] + ...

vec3 **cross**(vec3 *x*, vec3 *y*)	Returns the cross product of x and y, i.e.,
	result.x = *x*[1] · *y*[2] - *y*[1] · *x*[2]
	result.y = *x*[2] · *y*[0] - *y*[2] · *x*[0]
	result.z = *x*[0] · *y*[1] - *y*[0] · *x*[1]

TYPE **normalize**(*TYPE x*)	Returns a vector in the same direction as *x* but with a length of 1.

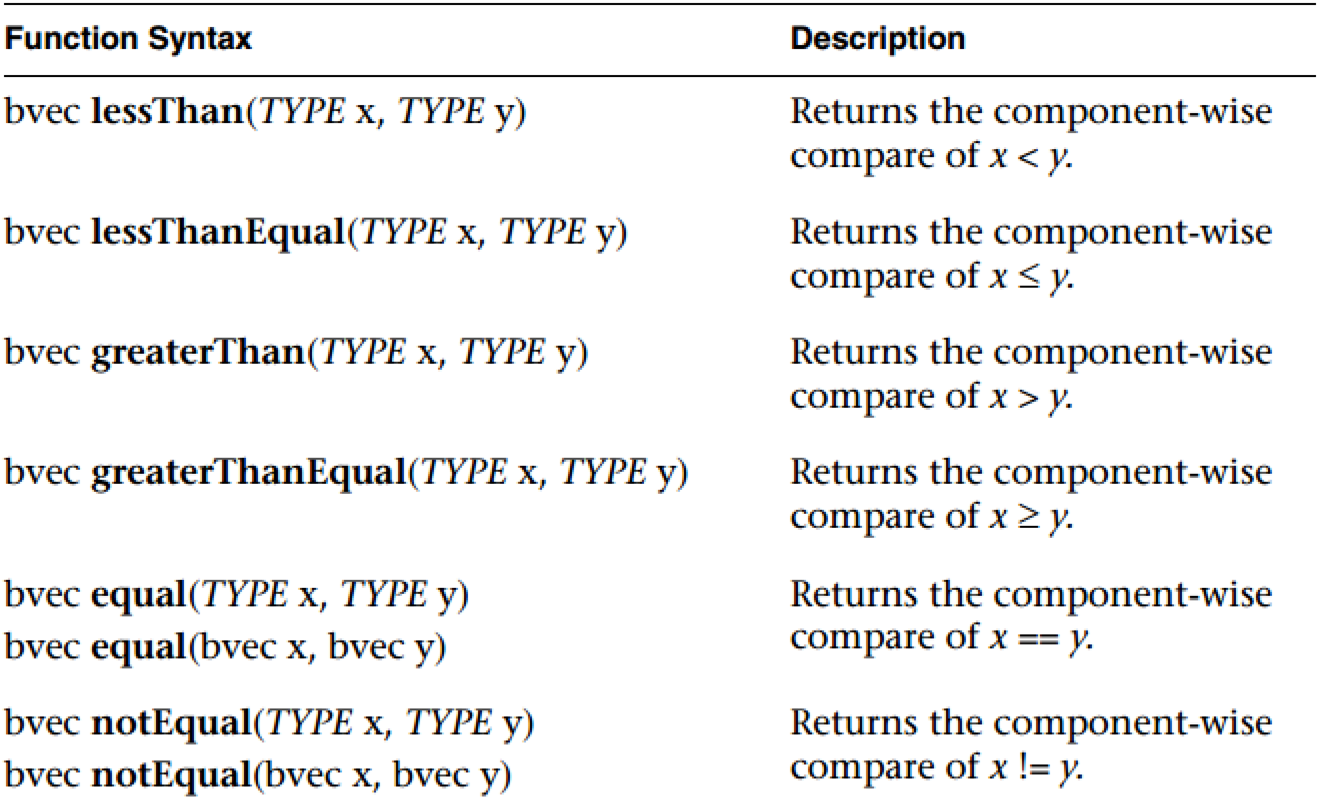
Built-In OpenGL Shading Language Functions



TYPE **reflect**(*TYPE I*, *TYPE N*)	Returns the reflection direction for incident vector I, given the normalized surface orientation vector *N*: result = $I - 2 \cdot \mathbf{dot}(N, I) \cdot N$
TYPE **refract**(*TYPE I*, *TYPE N*, float *eta*)	Returns the refracted vector *R*, given the normalized incident vector *I*, normalized surface normal *N*, and ratio of indices of refraction *eta*. The refracted vector is computed in the following manner: $k = 1 - eta^2(1 - (\hat{N} \bullet \hat{I})^2)$ $\vec{R} = \begin{cases} 0 & k < 0 \\ (eta \cdot \hat{I} - eta\hat{N} \bullet \hat{I} + \sqrt{k}\hat{N}) & k > 0 \end{cases}$

Built-In OpenGL Shading Language Functions

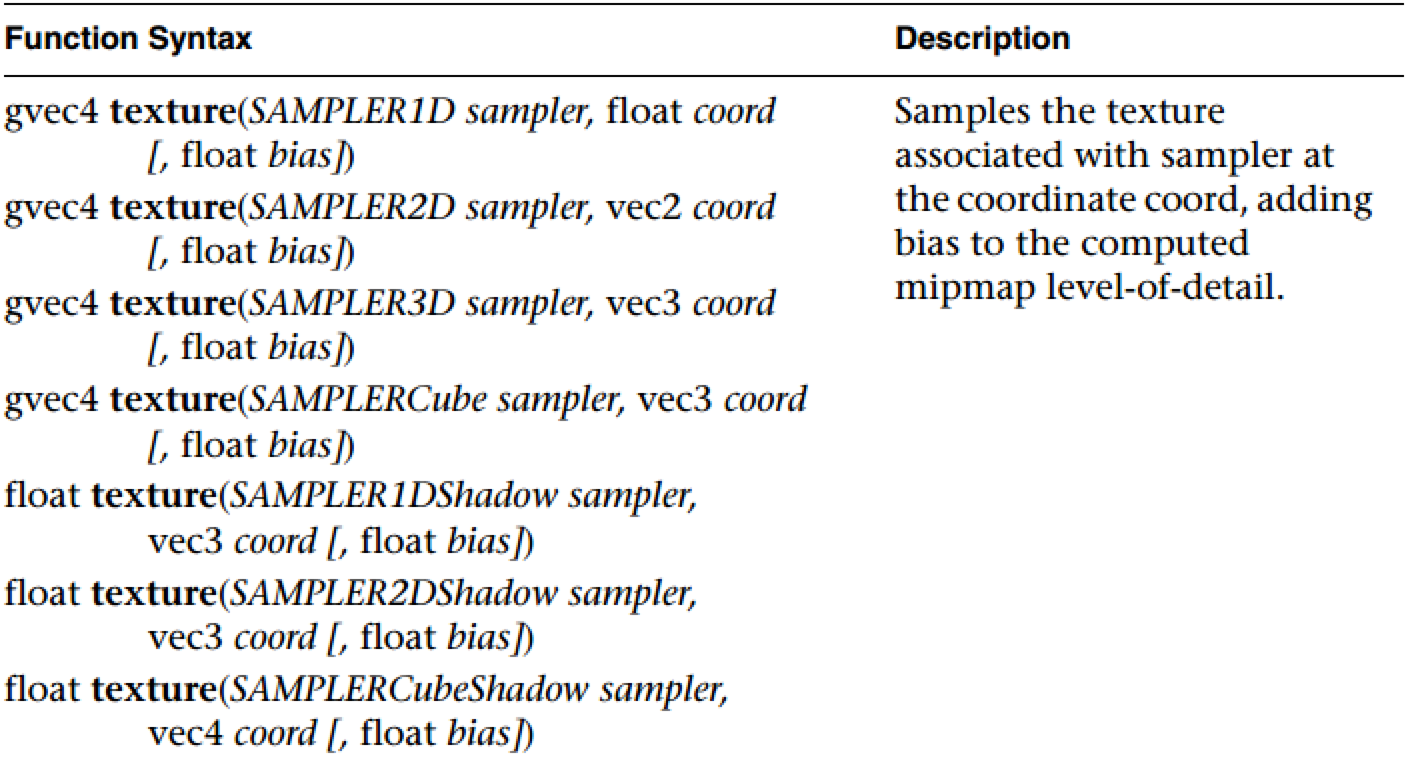
- Vector Component Relation Functions



Function Syntax	Description
bvec **lessThan**(*TYPE* x, *TYPE* y)	Returns the component-wise compare of $x < y$.
bvec **lessThanEqual**(*TYPE* x, *TYPE* y)	Returns the component-wise compare of $x \leq y$.
bvec **greaterThan**(*TYPE* x, *TYPE* y)	Returns the component-wise compare of $x > y$.
bvec **greaterThanEqual**(*TYPE* x, *TYPE* y)	Returns the component-wise compare of $x \geq y$.
bvec **equal**(*TYPE* x, *TYPE* y) bvec **equal**(bvec x, bvec y)	Returns the component-wise compare of $x == y$.
bvec **notEqual**(*TYPE* x, *TYPE* y) bvec **notEqual**(bvec x, bvec y)	Returns the component-wise compare of $x \mathrel{!=} y$.

Built-In OpenGL Shading Language Functions

- Basic Texture Access Function



Function Syntax	Description
gvec4 **texture**(*SAMPLER1D sampler*, float *coord* *[*, float *bias]*)	Samples the texture associated with sampler at the coordinate coord, adding bias to the computed mipmap level-of-detail.
gvec4 **texture**(*SAMPLER2D sampler*, vec2 *coord* *[*, float *bias]*)	
gvec4 **texture**(*SAMPLER3D sampler*, vec3 *coord* *[*, float *bias]*)	
gvec4 **texture**(*SAMPLERCube sampler*, vec3 *coord* *[*, float *bias]*)	
float **texture**(*SAMPLER1DShadow sampler*, vec3 *coord [*, float *bias]*)	
float **texture**(*SAMPLER2DShadow sampler*, vec3 *coord [*, float *bias]*)	
float **texture**(*SAMPLERCubeShadow sampler*, vec4 *coord [*, float *bias]*)	